Sensor for Dual Wavelength Bands

Field of the Invention

The present invention relates to sensors, and in particular to a sensor for at least two wavelength bands such as infrared and visible color wavelengths.

Background of the Invention

Microbolometer arrays are arrays of IR sensors used to sense infrared (IR) light. The sensors are formed in an array on a semiconductor substrate in a well known manner. IR light is focused on the array via optics. When coupled to a display, the microbolometer array provides a heat based (IR) image, such as currently used in some automobiles to provide night vision to a driver. These have been extremely useful for providing visual images of humans and other animals well before they can be seen by the eye with the aid of headlights.

One problem associated with such displays is that they do not show other information which is required for safe driving, such as traffic control lights. The display may show whether a light is on or off by the heat that it generates, but the heating effect is slow and hence is not a reliable indication . Thus, there is no way to safely determine the color of the light. It should be noted that some states allow lights to be positioned horizontally. Remembering which side of the light is red may be difficult for many drivers.

Summary of the Invention

A dual wavelength focal plane has a first array of infrared sensing pixel elements and a second array of visible light pixel elements adapted to be selective to colors encountered while driving an automobile. The second array is selective to the colors red, blue and green, corresponding to traffic control signals, including brake lights of other automobiles.

In one embodiment, the first and second arrays are fabricated on a monolithic silicon substrate. The arrays are electrically coupled to a processor and display to integrate the infrared and color pixel elements into a view for a driver of the automobile.

In a further embodiment, the second array comprises sets of three silicon photodiodes adapted to be selective to red, blue and green respectively, each set of photodiodes formed on the silicon substrate beneath the infrared sensing pixel element.

A heads up display for enhancing visibility for night time drivers of vehicles is provided by sensing infrared radiation sources generally in the path of the vehicle, selectively sensing visible radiation corresponding to traffic control colors, and combining the sensed visible radiation and infrared radiation to provide images for the heads up display. The traffic control colors are displayed in color.

In still a further embodiment, a CCD array is used as the second array for sensing visible light. The processor then utilizes digital filtering to separate out red, amber and green traffic control colors and superimposes those on the image from the infrared sensing array.

Brief Description of the Drawings

Figure 1 is a block cross section of a substrate having sensors for multiple wavelengths.

Figure 2 is a block diagram of a system for displaying images produced by an array of sensors from Figure 1.

Detailed Description of the Invention

In the following description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural, logical and electrical changes may be made without departing from the scope of the present invention. The following description is, therefore, not to be taken in a limited sense, and the scope of the present invention is defined by the appended claims.

A single monolithic un-cooled silicon focal plane is shown generally at 110 in Figure 1. The focal plane is capable of imaging both infrared (IR) and visible

wavelengths. One pixel is shown in Figure 1. The pixel is formed on a silicon substrate 115, and comprises a infrared-sensitive pixel 135 and a plurality of visible-light photosensors 120, 125 and 130, corresponding to selected colors. A filter is provided for each photosensor as indicated at 122, 127 and 132, to make the photosensors sensitive to certain colors, such as red, blue and green light bandwidths respectively. Such bandwidths generally correspond to vehicle traffic control signals. Vehicles include for example, automobiles, trains, boats and airplanes, as well as other vehicles. The photosensors may be made selective to other colors as desired.

In one embodiment, a single visible photosensor is fabricated with each bolometer pixel, and only red light is allowed to fall onto the array, by means of a red filter in the optical path.

A microbolometer 135 is formed above the photosensors and separated therefrom by a thermally-isolating space. The microbolometer may be formed in many different ways as shown in the art, but with minimal metalization to enhance transmission of visible light to the underlying visible photosensors. When formed in this manner, the microbolometer and photosensors are vertically stacked on a monolithic silicon substrate. The arrays are vertically integrated into an monolithic silicon substrate to optimize fill factor.

A system for providing a heads up display is shown in Figure 2. An array of pixels comprising the focal planes of Figure 1 are shown in a partial cutaway block representation at 210. Connections to each of the sensors in each pixel are represented at 215, and are made in any of many well known manners. The connections 215 are coupled to a processor 220. Processor 220 is formed in the same substrate as the array of pixels in one embodiment, or may be an independent processor. Processor 220 processes the inputs from the array 210 to combine the IR monochrome image signals with the photosensor color signals to provide an image for display by display 230, such as a common heads up display. The processor may also be integrated into display 230. The display 230 provides a monochrome image corresponding to the IR signals, overlaid with colors provided by the photosensors.

By sensing IR sources generally in the path of the vehicle, selectively sensing visible radiation corresponding to traffic control colors, and combining the sensed visible

radiation and infrared radiation to provide images for the heads up display, traffic control colors are displayed in color over a monochrome representation of the sensed IR.

5